A Safety Monitoring And Control System For Process Plant Using Programmable Logic Controller Via Function Block Diagram Programming

by

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16778

Dissertation submitted in partial fulfillment of
the requirements for the
Bachelor of Engineering (Hons)
(Electrical and Electronics)

JANUARY 2015

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CERTIFICATION OF APPROVAL

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Approved by,

____

(ASSOC. PROF. DR. NORDIN BIN SAAD)

UNIVERSITI TEKNOLOGI PETRONAS
BANDAR SERI ISKANDAR PERAK
January 2015

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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SITI AISYAH BT ABD. RAHAMAN

ABSTRACT

This project is about a safety monitoring and control system of process plant to provide better automated supervision for a plant with minimum human intervention in making decision depends on the plant's status. The system is programmed by using functional block diagram (FBD) which is one of graphical language standardize by IEC 6133-3. The robustness of FBD makes it compatible to be use for system which required complex and critical decision making. Besides, human machine interface (HMI) is also integrated in this project for monitoring and controlling purpose. The aim is to design a system for monitoring and controlling purpose with safety consideration and integrate the system with an HMI as one complete system. The steps taken to accomplish this project are discussed in detail. The deliverables of the project would be a safety and control system programmed based on the cause and effect using FBD, graphic interfacing for the system and the integration between the FBD and HMI. Analysis of integration is done afterward to ensure the system is working as expected.

Keywords-*safety monitoring; control system; functional block diagram (FBD); human machine interface (HMI)*

ACKNOWLEDGEMENT

First and Foremost, I am grateful to Allah S.W.T. for the blessing and strength that has provided me with the inspirations to pursue and finally, completed my two semester of Final Year Project (FYP) I and II

With all the unexplored challenges waiting for me prior to the completion of FYP, I am forever thankful to my beloved family, who has given me the never-ending support to ensure that I have the courage and perseverance to go through difficulties and obstacles.

My upmost gratitude is also addressed to my supervisor, Assoc. Prof. Dr. Nordin Saad for his supervision, patience and advices throughout this course. Besides to those people who have helped me during the completion of my project. These include my internship colleague at TriSystem Engineering Sdn. Bhd for the advices and not forgetting the lab technician Mr. Azhar for the assistance in preparing the lab for the project purpose.

Last but not least, thank you to everybody who has contributed directly or indirectly towards finishing the project.

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LIST OF ABBREVIATIONS

CEM : Cause and effect matrix
CSTR : Continuous stirred tank reactor
DDE : Dynamic Data Exchange
FBD : Function block diagram
HMI : Human Machine Interface
IEC : International Electrotechnical Commission
LAN : Local Area Network
P&ID : Piping and instrumentation diagram
PLC : Programmable Logic Controller
SIL : Safety Integrity Level
SM : Safety monitoring
WMI : Waterfall methodology with iteration

CHAPTER 1
INTRODUCTION

1.1 Background

The growing complexity of industrial process requires an adequate level of controlling and monitoring as the industry is looking into an automated system for reliability, speed and cost effectiveness. Failure in discovering the faulty condition in a process will not only cause millions to the company, but also could lead to loss of life. September 9th, 2010 witnessed the damage caused by a blast because of a high pressure in gas pipeline in San Bruno, a suburb of San Francisco [1]. The table below shows the effect of the incident:

Table 1: Effects of pipeline exploded in San Bruno

Destroyed homes	38
Damaged houses	120
Loss of life	8
Total burned area	10 acres

Recently, many studies have been conducted about implementing effective monitoring of the industry, including process monitoring and failure detection to prevent the probability of hazard to occur. Hence a safety monitoring, with efficient control system is expected to satisfy the urgent need in various fields of industry.

Safety monitoring (SM) is an error detection and recovery system which activated when the violation occurred in safety hazard. Nowadays it is a normal practice in the industries to have a calibration of SM with the graphical interface so that monitoring and controlling purpose can be done simultaneously. Therefore the implementation of reliability engineering in designing a safety monitoring and control system is an essential key point to remain the availability of a plant.

1.2 Problem Statement

As much as the safety is taken care greatly by the system, monitoring of the system such as a Human Machine Interface (HMI) – controller network is needed to perform the alarm monitoring and perform P, PI, PD, PID control of the system.

This project would address the safety and alarm system of a process plant with several variables (Pressure, Level, Flow, and Temperature) using TRISTATION 1131 (software equivalent of a TRICONEX Programmable Logic Controller (PLC)) and to perform PID control on the respective actuators of the plant, the monitoring and control operations should be accurately and efficiently address the performance and safety. Hence, to develop a logic program for the TRISTATION 1131 would involve an in-depth engineering study and design.

On the other hand, a specific HMI program is created for friendly monitoring purposes. The application needs to be user friendly and need to do the entire task as running in logic program (PLC). Besides, the application must be able to read the information that has been pumped to the server‘s PC and also compatible with the server as well as the PC to run the application smoothly.

1.3 Objectives

The main objectives of this project are as follows:

- To design a safety system using a cause and effect matrix.
- To develop and construct a logic function block diagram for the system via TRISTATION 1131 graphical programming.
- To develop an HMI using compatible graphic software for monitoring and control purpose.
- To understand the integration protocol between PLC and HMI using dynamic data exchange (DDE) server.

CHAPTER 2
LITERATURE REVIEW

Designing a safety and monitoring system would involve an in-depth engineering study, including critical plant analysis, programming, HMI design and communication. The literature review is focusing on the design approach of the system.

2.1 Cause and Effect Matrix (CEM)

Cause and effect matrix (CEM) as shown in Figure 1 is widely used in the practice of developing a logic system. It is put in a readable matrix format which has two major components. These two components are the causes that meant to be the identified problems, meanwhile the effects are the actions taken. The cause and effect are located in the row and column of the matrix respectively [4].

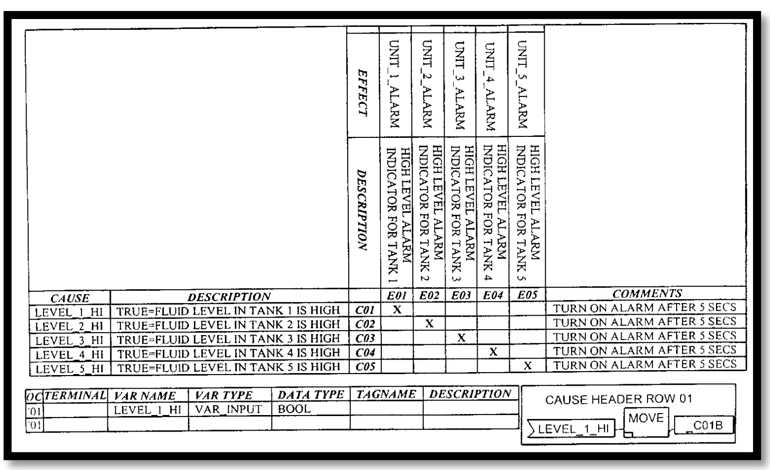


Figure 1 : Cause and effect matrix [4]

In NORSAK standard for system control diagram revision 2, cause and effect is an important element in developing the programming of the safety system as can be seen in Figure 2:

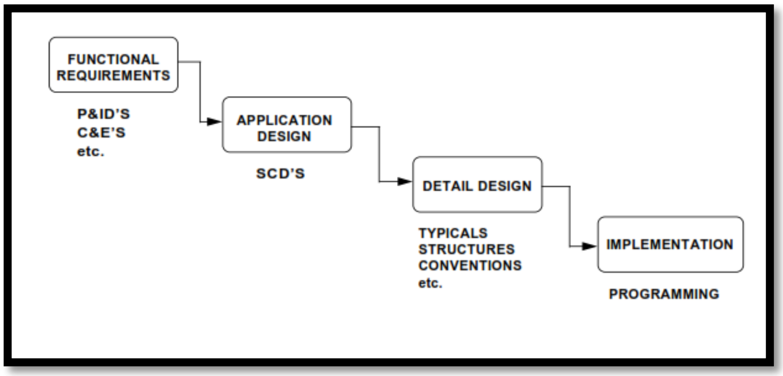


Figure 2: Object typical for programming development [5]

2.2 Triconex – Tricon

Tricon is a fault tolerant controller from the Triconex range. The implementation of triple modular redundant (TMR) makes Tricon one of the most trusted safety controllers which have a very high integrity safety. It was designed to cater critical application requiring Safety Integrity Level (SIL) 1, 2 and 3 such as emergency shutdown system (ESD) and burner management system (BMS). Besides, the programming software is compliant with IEC 1131-3 which offers simple programming like functional block diagram, ladder diagram and structured text for easy configuration and program emulation [16].

Figure 3: Tricon controller [16]

2.3 Function Block Diagram (FBD)

Function block diagram is one of the graphical languages that extensively use in programmable logic controllers (PLC). It falls under the IEC 61131-3 which is the International Electrotechnical Commission (IEC) standards for PLCs language [6]. The flexibility and ease of use of FBD make it easier to be applied in various applications [7]. Besides, recent studies show the capability of FBD in handling complex tasks as safety-critical is proven in rail automation [8], air traffic control, patient monitoring and emergency shut down systems in various types of plants [9]. Figure 3(a) and 3(b) below shows the example of construction of DEBOUNCE function block using FBD [9]:

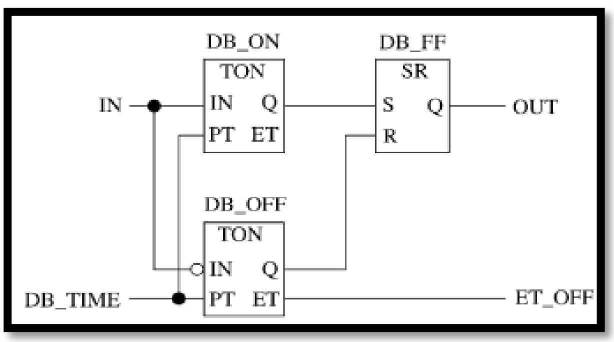


Figure 4(a) :
Components in function block DEBOUNCE [9]

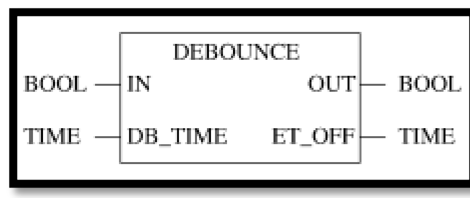


Figure 4(b) :
Exterior of function block DEBOUNCE [9]

2.4 Human Machine Interface (HMI)

According to Scott (2013), HMI is a real-time display of a process. Commonly HMI is designed to be a friendly user to the operator as it serves as an interface between a man and machine. A HMI could be as simple as a big monitor panel for the ease of observation purpose [10] with an engineering workstation for controlling the operation. There are numbers of protocols in integrating a HMI and PLC. Some are listed below as stated in [11]:

- Ethernet
- Profibus-DP
- Modbus-RTU

2.5 Dynamic Data Exchange (DDE)

Integration between two electronic devices using Microsoft Windows can be achieved by DDE server. DDE is a built in protocol, which allows sharing data when these two devices are connected through Ethernet as well as Internet [12]. The connection will create a server-client network where the PLC is set as server and the HMI as the client feed all data to the server [13].

2.6 Case Study – Continuous stirred tank reactor (CSTR)

A case study of CSTR is taken to be implemented in this project. The equation of the process is given by:

$$A + B \rightarrow AB$$

The processes are:

1. B is added slowly into a full charge of A
2. Maintain the mixing temperature at TR
3. C is added to AB. (this process is ignored in this project)
4. AB is cooled to TP before leaves the tank as final product.

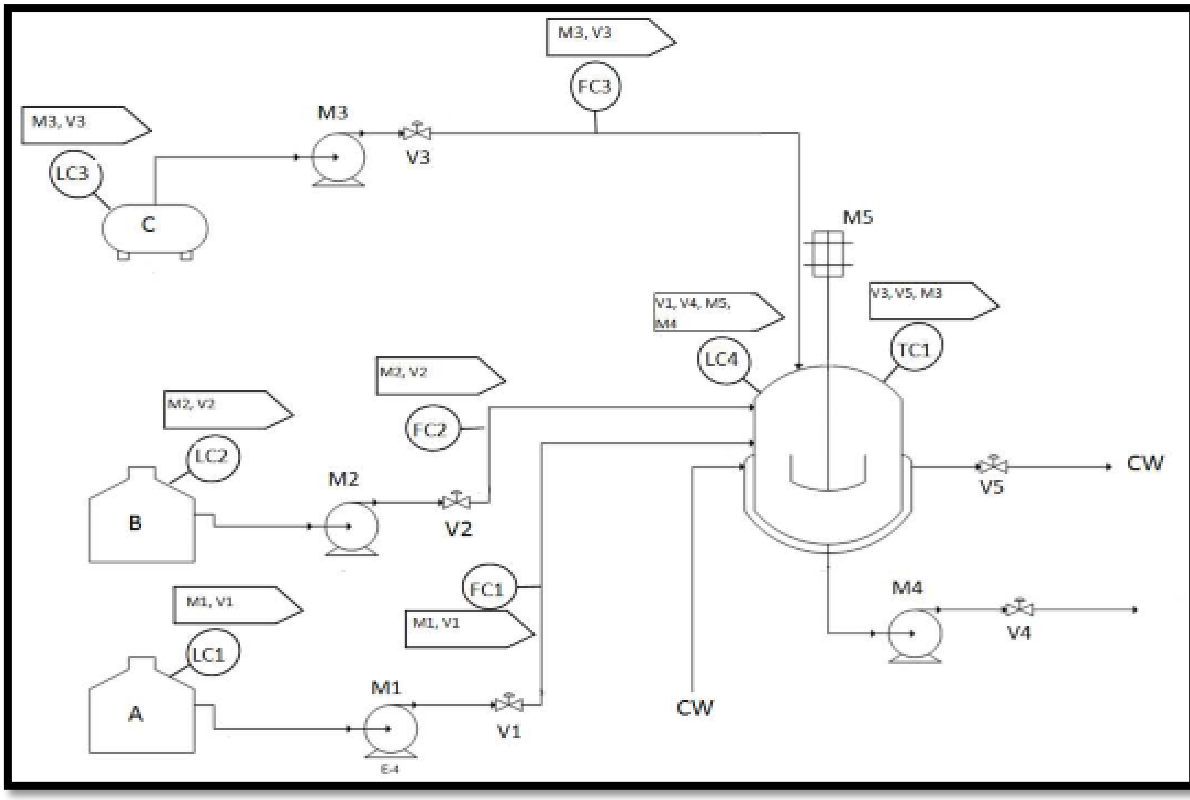


Figure 5: P&ID diagram of a CSTR proposed by [15]

The following aspects are needed to be produced based on the given process flow and the P&ID as shown in Figure 4:

1) New P&ID drawing: The system is simplified by eliminating C from the existing process and safety elements will be added.

2) Control narrative: Clear information on location, action, set points and alarms are provided for each element.

3) Cause and effect matrix: Mapping of input and output to discover factors that affect the outcomes.

The informations are useful in developing the logic of the system later.

CHAPTER 3
METHODOLOGY

3.1 Waterfall Methodology with Iteration

To facilitate the system development project, the waterfall methodology with iteration (WMI) is the best approach to manage the performance of the project flow. Unlike the standard waterfall methodology, WMI has the feedback to decrease the probability of failure at the end of the product.

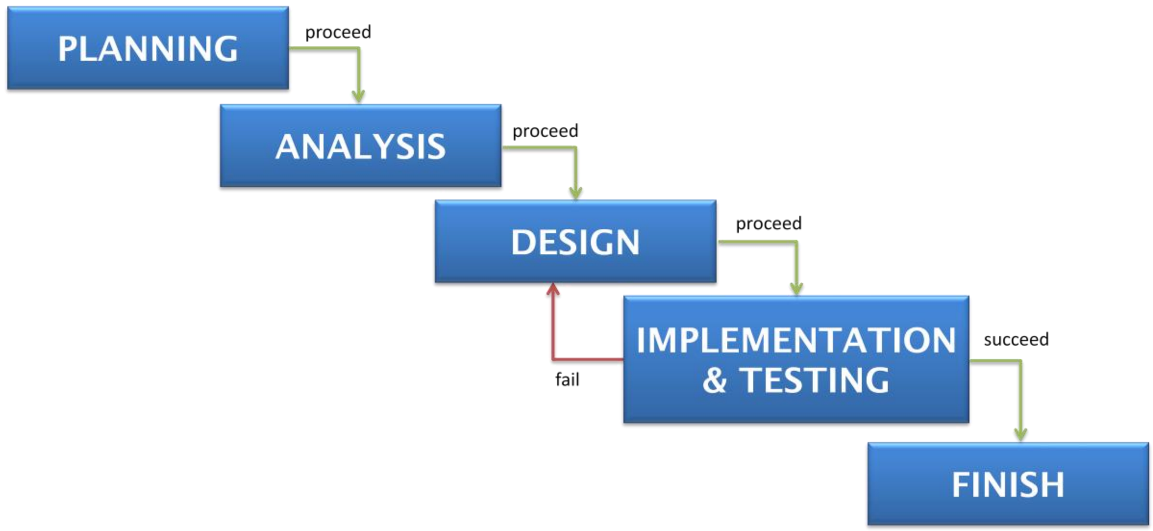


Figure 5: WMI for a System Development Life Cycle [14]

Table 2: Steps implementation table

Steps	Execution
1) Planning	• Background study • Problem statements • Objectives
2) Analysis	• Literature review • Case study identification • Producing control narrative based on case study • Research on compatible HMI
3) Design	• Cause and effect matrix • Function blocks for analog transmitter • Construct logic for each controller in the systems. • Logic expansion for the whole system. • Graphic for HMI • Mapping logic address to HMI • Critical logic development
4) Implementation and testing	• Integration of logic and HMI • Testing and trouble shooting • Final alteration for logic and HMI

3.2 Gantt Chart

WMI is also implemented in the Gantt chart for this project which is for FYP 1 and FYP 2 as attached respectively in the appendix 1 and 2.

3.3 Project Flow

This project flow can be simplified and illustrated as shown in the flow chart below:

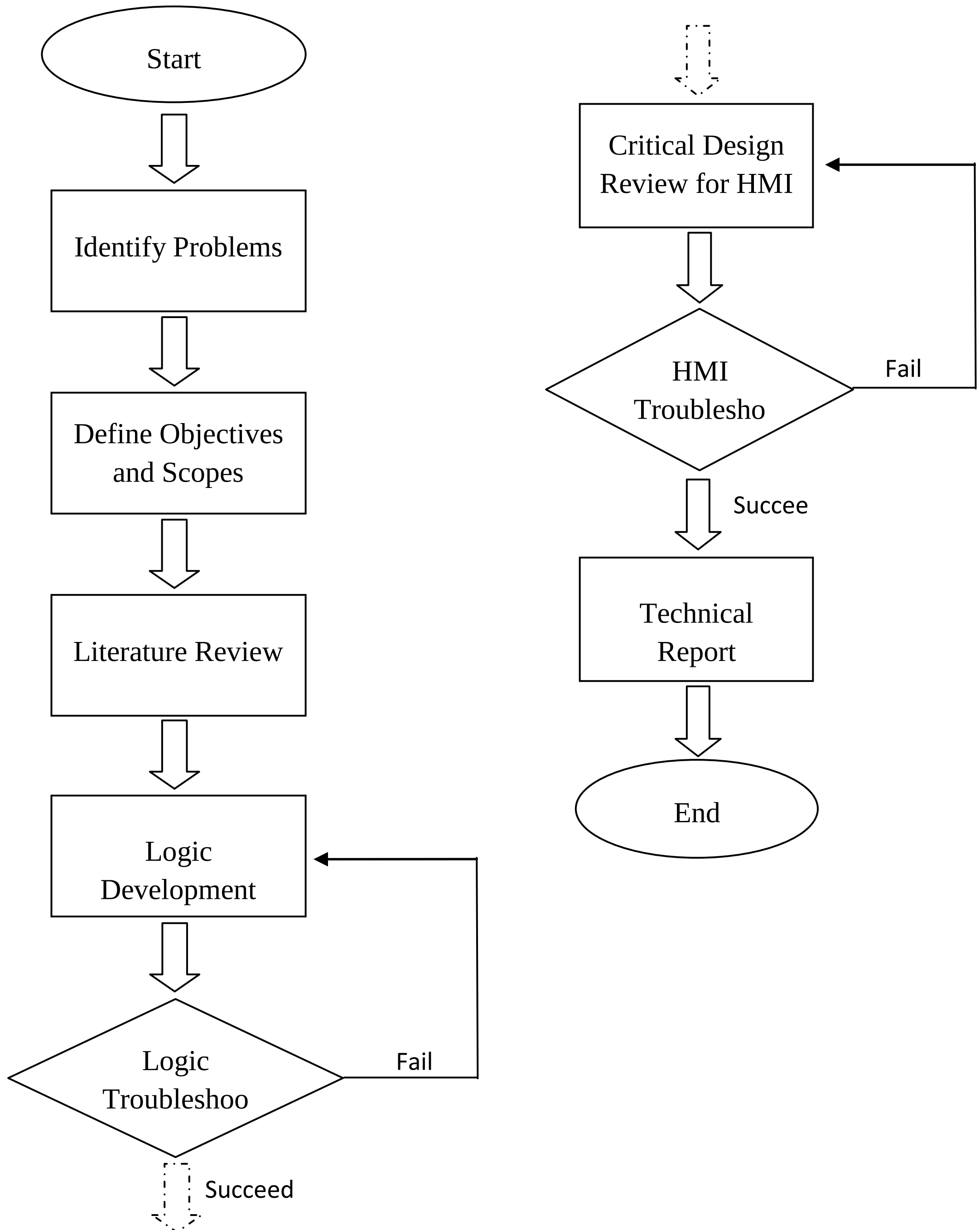


Figure 6: Flow chart of the project

Notes: Dash-dot lines denote the continuity of the flow chart

3.4 TOOLS AND SOFTWARE

The following lists below are the tools and software used in developing this project:

Table 3: Tools and software required for the project

Equipment / Software	Function
➢ TriStation 1131 4.10.1 (Industry Standard Development Software).	The platform to develop the logic program of the application.
➢ Wonderware InTouch 10.1 (demo version)	The platform to design HMI
➢ Edraw Max	To construct P&ID diagram
➢ DDE Server 4.3.0	It is a method of exchanging data between applications running on Windows operating system.
➢ Windows 7	Windows to run the application. This window is compatible with the office PC version.
➢ Laptop	The laptop is set as the workstation to run the logic.
➢ Desktop	The desktop is set as the HMI platform.
➢ Ethernet Switch	To connect workstation and HMI through Local Area Network (LAN).

CHAPTER 4
RESULTS AND DISCUSSION

This project is deliverables by developing a PLC logic program using TriStation TS1131 and a HMI graphic by Wonderware InTouch. These two software are then integrated to make a complete system via Triconex DDE client.

4.1 Safety System Design

4.1.1 New Piping & Instrumentation Diagram (P&ID)

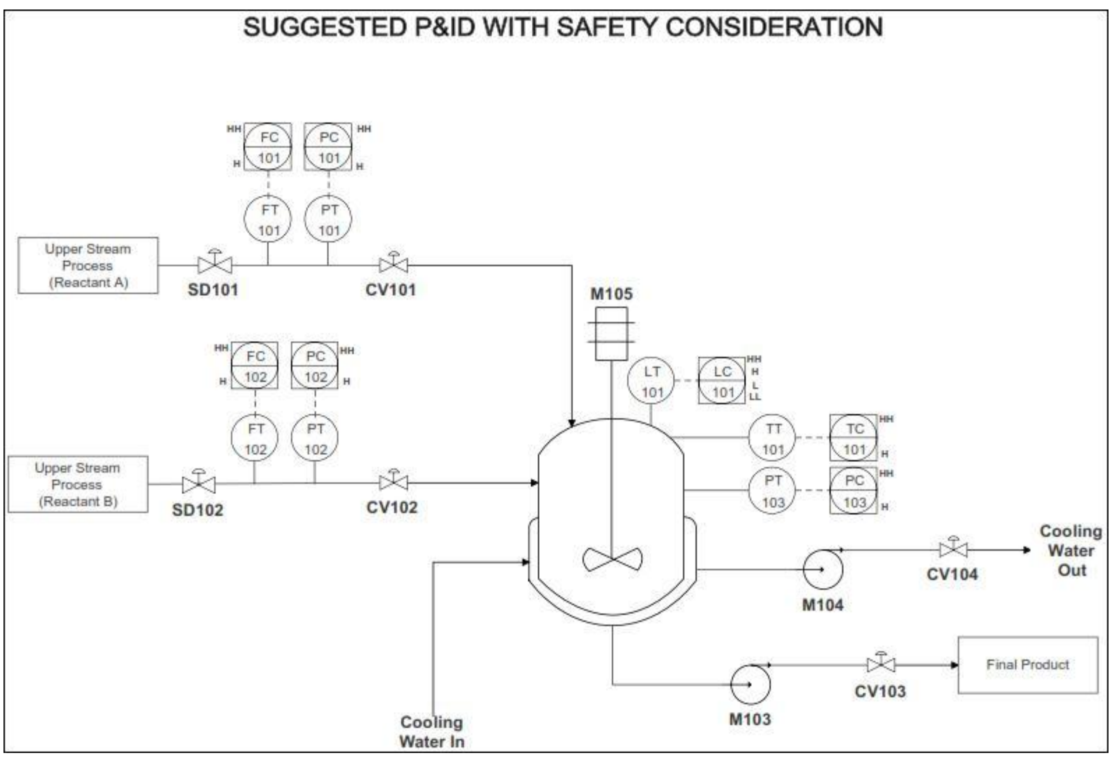


Figure 8: Suggested P&ID of the system with safety consideration

4.1.2 Control narrative

1) Mixture Level Control for CSTR Vessel

The level transmitter (LT101) is installed on CSTR to measure the mixture level inside the vessel. The level reading is monitored by several controller and actions are taken by respective controller assigned for pre-set reading.

Table 4: Description for level control

LOCATION	CSTR Level transmitter (LT101) is installed on CSTR Vessel. CV103 is on the product outlet line. M105 is the stirrer inside the CSTR.
ACTION	Direct PID control: • LC_101_A on CV103. ON/OFF control: • L = M105 STOP Alarm: • H – High alarm at HMI monitoring • HH – High high alarm at HMI and vote for shutdown SD101.
SETPOINTS	LL = 5% L = 10% H = 85% HH = 95%

2) Mixture Temperature Control for CSTR Vessel

The temperature transmitter (TT101) is installed on CSTR to measure the mixture's temperature inside the vessel. The temperature in the mixture is monitored and controlled by Temperature Controller (TC101). The mixture need to be cooled at pre-set temperature before being release as final product.

Table 5: Description for temperature control

LOCATION	CSTR • Temperature transmitter (TT101) is installed on CSTR Vessel. • Coolant control valve CV104 is installed on discharge line of coolant transfer pump to maintain the temperature in the reaction tank.
ACTION	Direct PID control: • TC_101_B on CV104 Alarm: • H – High alarm at HMI monitoring • HH – High high alarm at HMI and vote for shutdown SD101.
SETPOINTS	H = 85% HH = 95%

3) Flow Control & Monitoring of CSTR Vessel

The flow transmitter (FT101) is installed on CSTR A inlet line. The flow transmitter (FT102) is installed on CSTR B inlet line to measure inlet flowrate of A & B.

The flow of reactant A is monitored and controlled by Flow Controller (FC101) and give direct PID control to control valve CV101.

The flow of reactant B is monitored and controlled by Flow Controller (FC102). FC102 have a direct PID effect on CV102 and ON/OFF signal to M102.

Table 6: Description for flow control

LOCATION	CSTR Flow transmitter (FT101) is installed on A inlet line of CSTR vessel. Flow transmitter (FT102) is installed on B inlet line of CSTR vessel.
ACTION	Direct PID control: • FC101 on CV101 • FC102 on CV102 Alarm: • H – high alarm at HMI monitoring. • HH – High high alarm at HMI
SETPOINTS	H = 85% HH = 95%

4.1.3 Cause and Effect Diagram

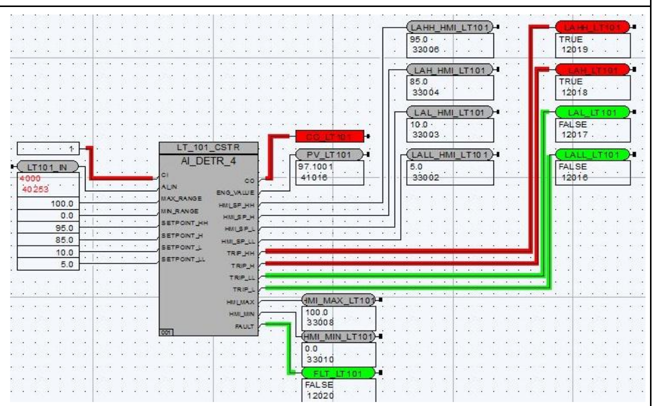
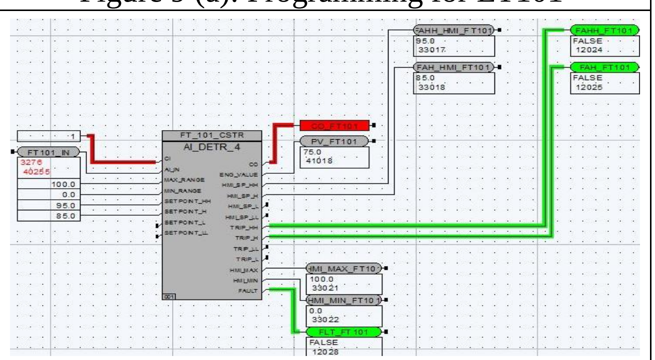
The result for this section is shown in the Appendix 1.

4.2 Logic Simulation on TriStation TS1131

TriStation TS1131 is a software application for developing, testing and documenting safety-critical and process control applications that execute on Triconex controller.

Table below shows the simulation result which run under automatic mode. Condition for each test is stated accordingly with the result.

Table 7: Results from TriStation 1131

Condition	Simulation Result
LT101 = 97%	 Figure 9 (a): Programming for LT101
FT101 = 75%	 Figure 9 (b): Programming for FT101

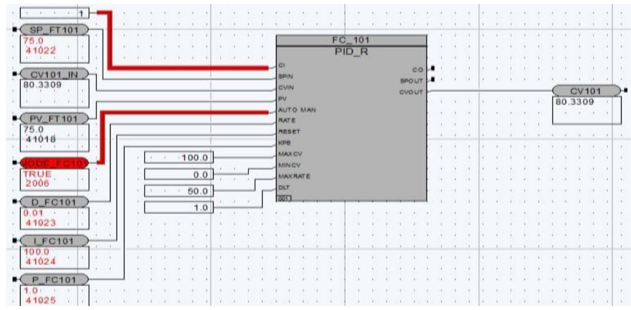
<table>
<tr><td>PV = SP
CV = 80%</td><td>

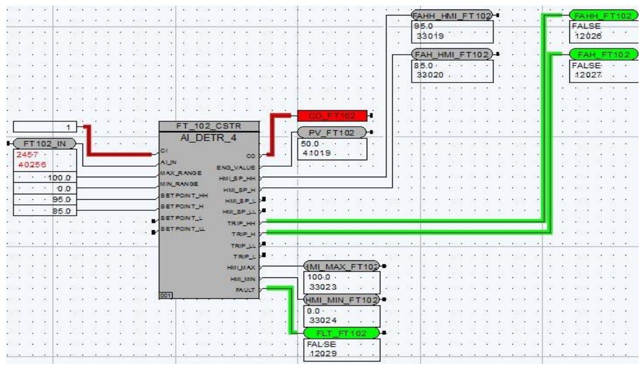
Figure 9 (c): Programming for FC101</td></tr>
<tr><td>FT101 =
50%</td><td>

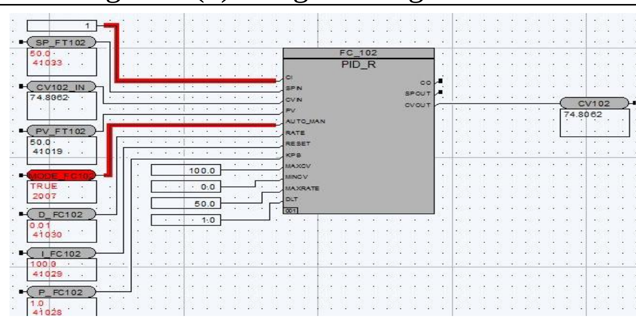
Figure 9 (d): Programming for FT102</td></tr>
<tr><td>PV = SP
CV = 74%</td><td>

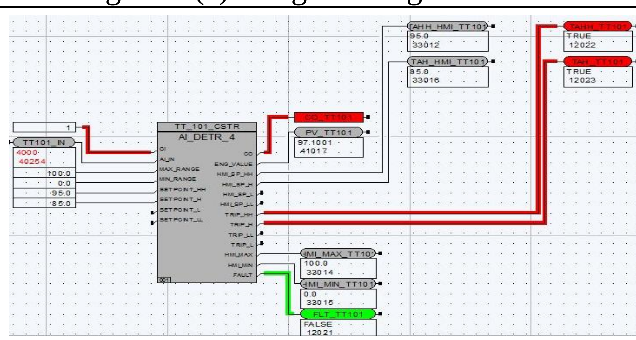
Figure 9 (e): Programming for FC102</td></tr>
<tr><td>TT101 =
97%</td><td>

Figure 9 (f): Programming for TT101</td></tr>
</table>

<table>
<tr>
<td>Temperature > limit, M103= OFF

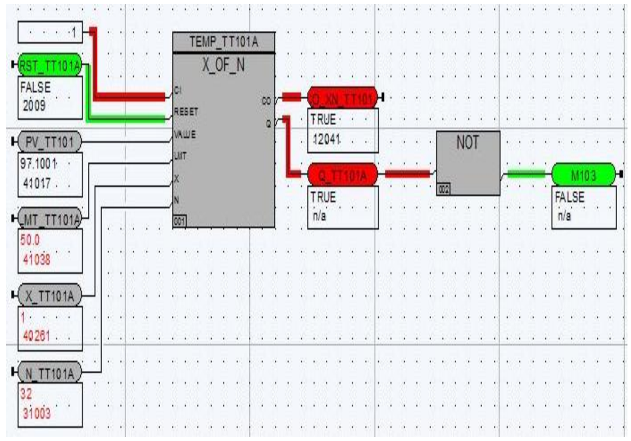
Temperature < limit, M103= ON</td>
<td>


Figure 9 (g): Programming for M103
</td>
</tr>
<tr>
<td>Two out of three voting:

SD101 :
PAHH_PT101
PAHH_PT102
LAHH_LT101

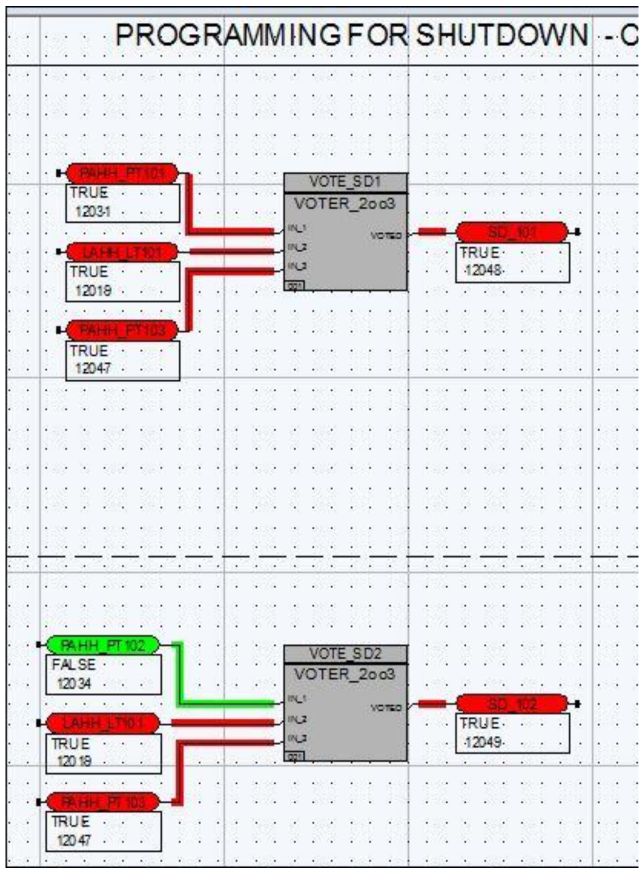
SD102 :
PAHH_PT102
PAHH_PT103
LAHH_LT101</td>
<td>


Figure 9 (h): Programming for shutdown
</td>
</tr>
</table>

4.3 Human Machine Interface (HMI)

Figures below are the HMI graphics by using demo version of Wonderware InTouch. The limitation of demo version is the number of windows that can be created in the program but this is not affected the design that had been created. Another major limitation for the demo version is the tagnames allowed for integration are restricted to 29 tags only.

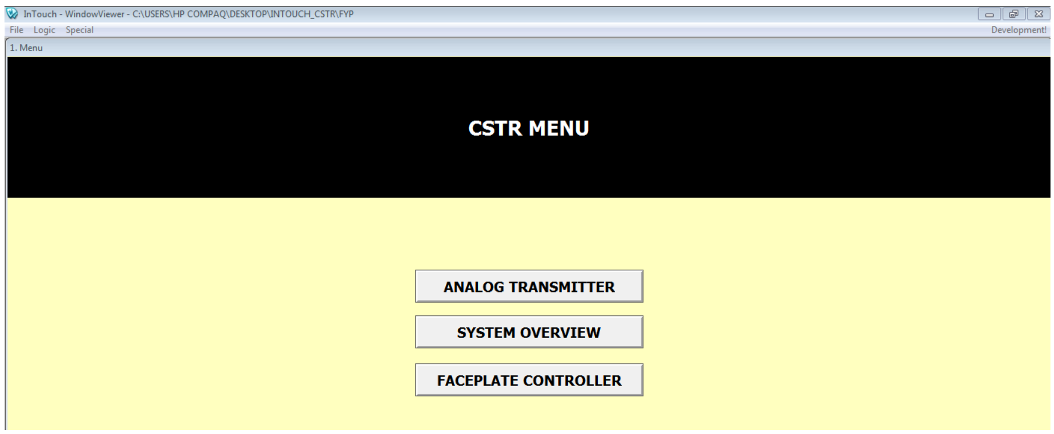


Figure 10: Menu window

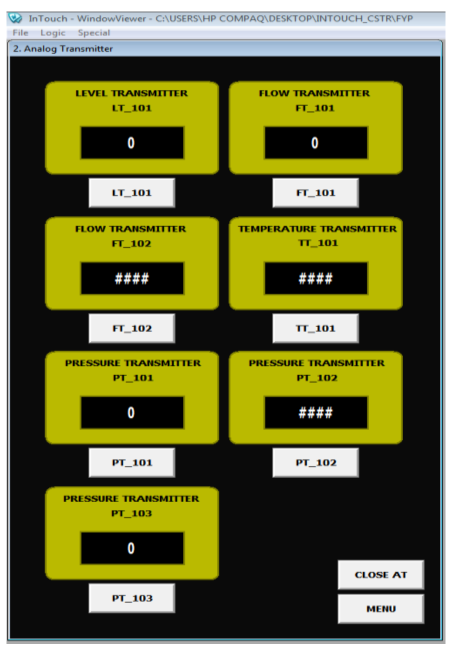


Figure 11: Analog transmitter window

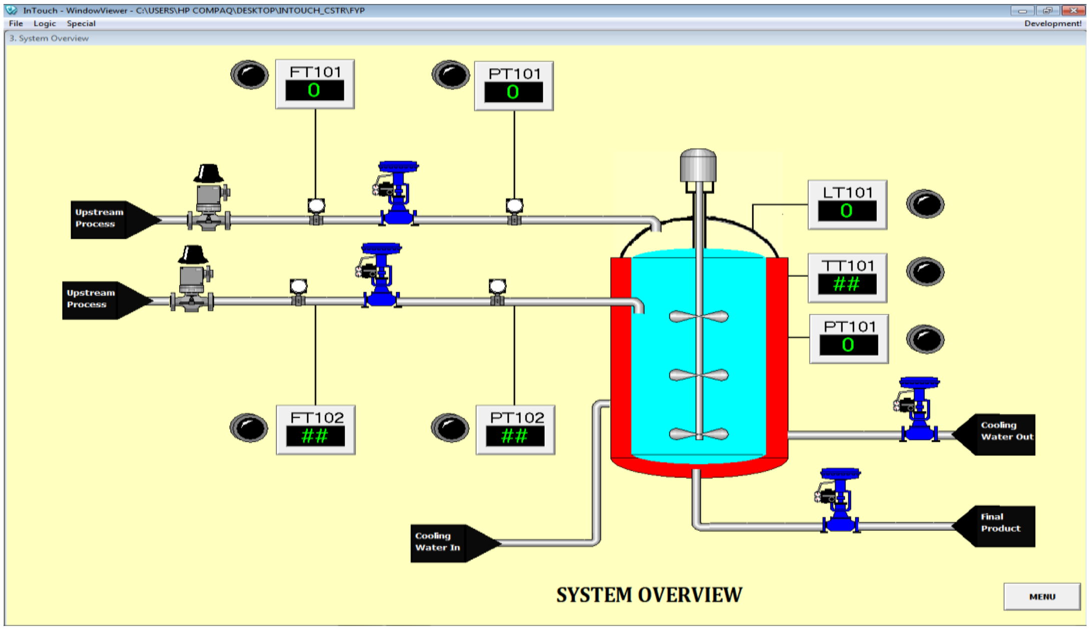


Figure 12: System overview

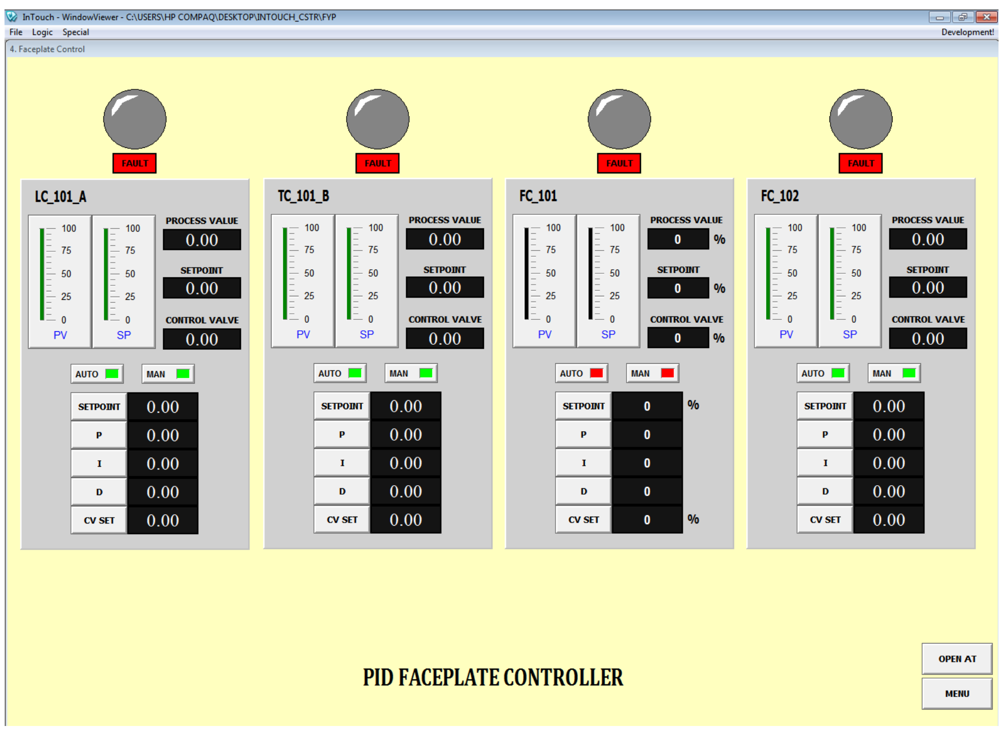


Figure 13: PID control faceplate controller window

4.4 System Integration

Integration between the PLC logic program and HMI was done using Triconex DDE 4.3. The communications between the DDE client (TriStation 1131 emulator) and the DDE Server (HMI software) have to pass through a software message routing mechanism in Windows.

After all communication configurations at the client's workstation (TriStation 1131 emulator) have been setup, a configuration at the DDE server is also needed. The following figures show the configuration and setup applied at the client and server workstation.

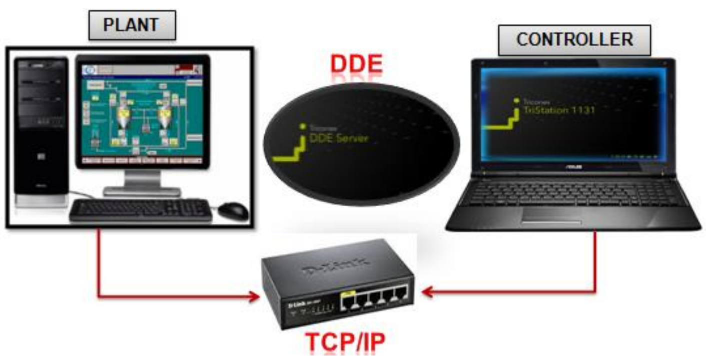


Figure 14: System Configuration

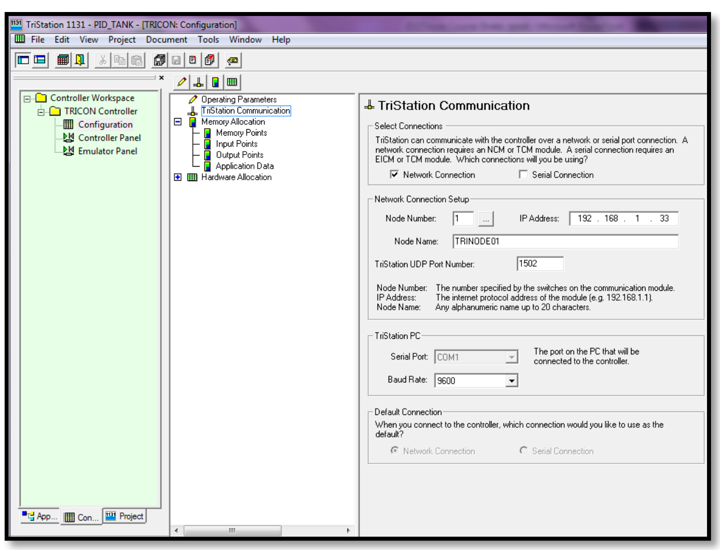


Figure 15: TriStation communation setting

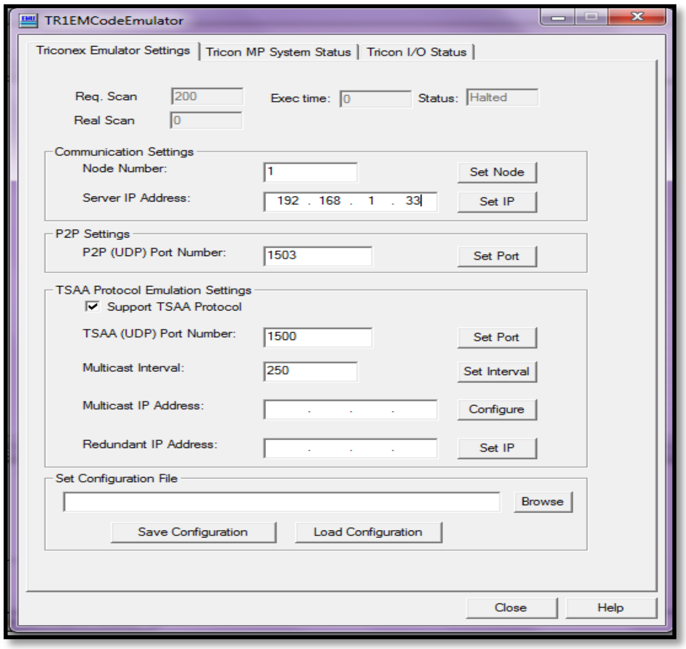


Figure 16: TriStation Emulator panel setting

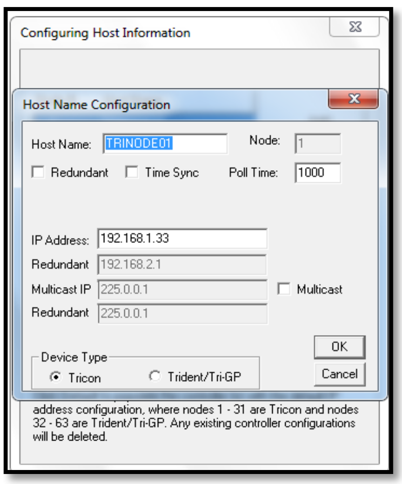


Figure 17: Configuration at the DDE server

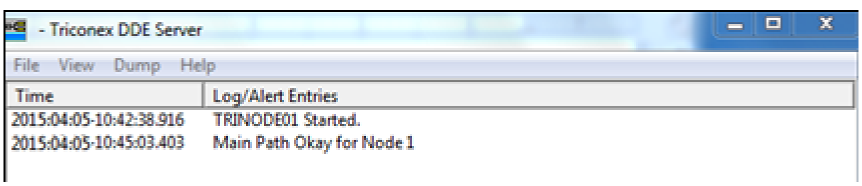


Figure 18: Message reply of the DDE server when the connection is established

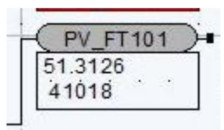
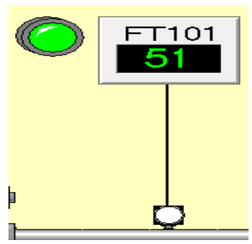
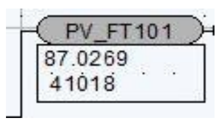
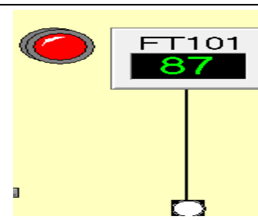
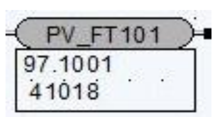
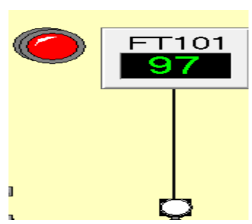
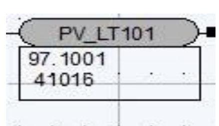
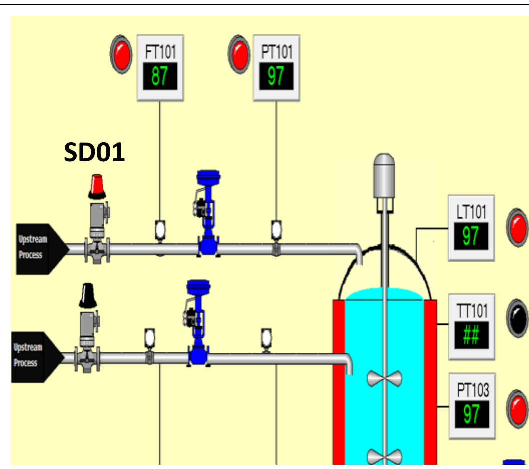
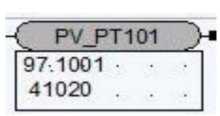
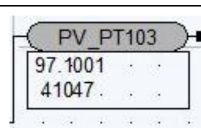
4.5 Discussion

This project was carried out by referring to a case study of CSTR process. The author had created a new P&ID diagram which shown the additional of pressure element to the plant for safety purpose. After that, a clear control narrative was produced to give a better understanding on the process and had the information of the causal relationship between the setpoint and the respective element in the plant. The causes and effects from the control narrative were then extracted and mapped in a cause and effect diagram which gives a clear vision for troubleshooting purpose.

The project continued with developing logic program using TriStation 1131 and HMI graphic by Wonderware InTouch. In this case, workstation with the logic program was set as controller and workstation with the HMI graphic as plant. The logic program can be simulated and verified the output by the software itself. Unlike TriStation, HMI graphic could not be demonstrated without integration with the logic program. Thus, a configuration and setup as shown in figure 14 until figure 17 were done to integrate both workstations. The result of creating a path for these two application s to communicate was shown in figure 18, said that the channel for the both software has been established. However the plant was not getting any signal from the controller because of the limitation from HMI demo version software. Thus, another configuration is made to solve this problem which is by using the same computer running both logic and HMI and integrate both softwares in the same computer. The integration was finally successful

The plant received signal from the controller and had displayed it at the HMI because the path was successfully created. Table 8 shows the integration results as achieved.

Table 8: Integration results

CONDITION	RESULT		ANALYSIS
	Logic Simulation (Process Value, PV)	**HMI**	
Flow transmitter FT101 = 50%			Normal Alarm color = Green
Flow transmitter FT101 = 87%			High alarm Alarm color = Red
Flow transmitter FT101 = 97%			High High alarm Alarm color = Red with blinking
Level transmitter LT101 = 97%			High High alarm Vote 2oo3 for shutdown valve **SD01**
Pressure transmitter PT101 = 97%			
Pressure transmitter PT103 = 97%			

CHAPTER 5
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

For overall, this project is presented as planned in the objectives. The cause and effect diagram (Appendix 3) is successfully mapped based on the control narrative as shown in chapter 4.1.2. From the cause and effect diagram, the logic program using FBD was able to be created and simulated as shown in the result 4.2. Besides that, the HMI graphics still can be designed even though the software is only a demo version. On the other hand, the integration between both software was done in the same computer because of limitation on HMI software. As a conclusion, the all objectives for this project are successfully achieved.

5.2 Recommendation

To improve the safety of this project, it is good to have a trending reading of the sensor elements which indicates the plant's state and healthiness of the devices at the HMI. Thus, the pattern of each element could be monitored and early action could be taken if something is showing out of the acceptable pattern region. Besides, logging system in sequence of event could be implemented to find the root cause of the trip or shutdown in the plant.

CHAPTER 6
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APPENDICES

APPENDIX 1 – GANTT CHART FYP 1

APPENDIX 2 – GANTT CHART FYP 2

APPENDIX 3 – CAUSE AND EFFECT MATRIX

APPENDIX 4 – EXAMPLE FBD PROGRAMMING

APPENDIX 1 – GANTT CHART FOR FYP 1

Activities for FYP 1	Week													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
PROJECT SELECTION														
PLANNING														
- Background study														
- Problem statement														
- Objectives														
ANALYSIS														
- Literature review														
- Identify case study														
- Study on control narrative														
- Research for compatible HMI														
EXTENDED PROPOSAL														
Extended proposal draft preparation														
Extended proposal submission														
DESIGN														
- Cause and effect matrix														
- Progress in dummy logic														
- Expand logic construction														
PROPOSAL DEFENSE														
Proposal defense draft preparation														
Proposal defense presentation														
INTERIM REPORT														
Interim report draft preparation														
Interim report submission														

APPENDIX 2 – GANTT CHART FOR FYP 2

Activities for FYP 2	**Week**														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
DESIGN															
- Graphic for HMI															
- Mapping logic address to HMI															
- Critical logic development															
IMPLEMENTATION AND TESTING															
- Integration of logic and HMI (DDE)															
- Testing and troubleshooting															
PROGRESS REPORT															
Progress report draft preparation															
Progress report submission															
FINAL REPORT															
Draft final report															
Final Report and Technical Paper															
VIVA															
Final Presentation															

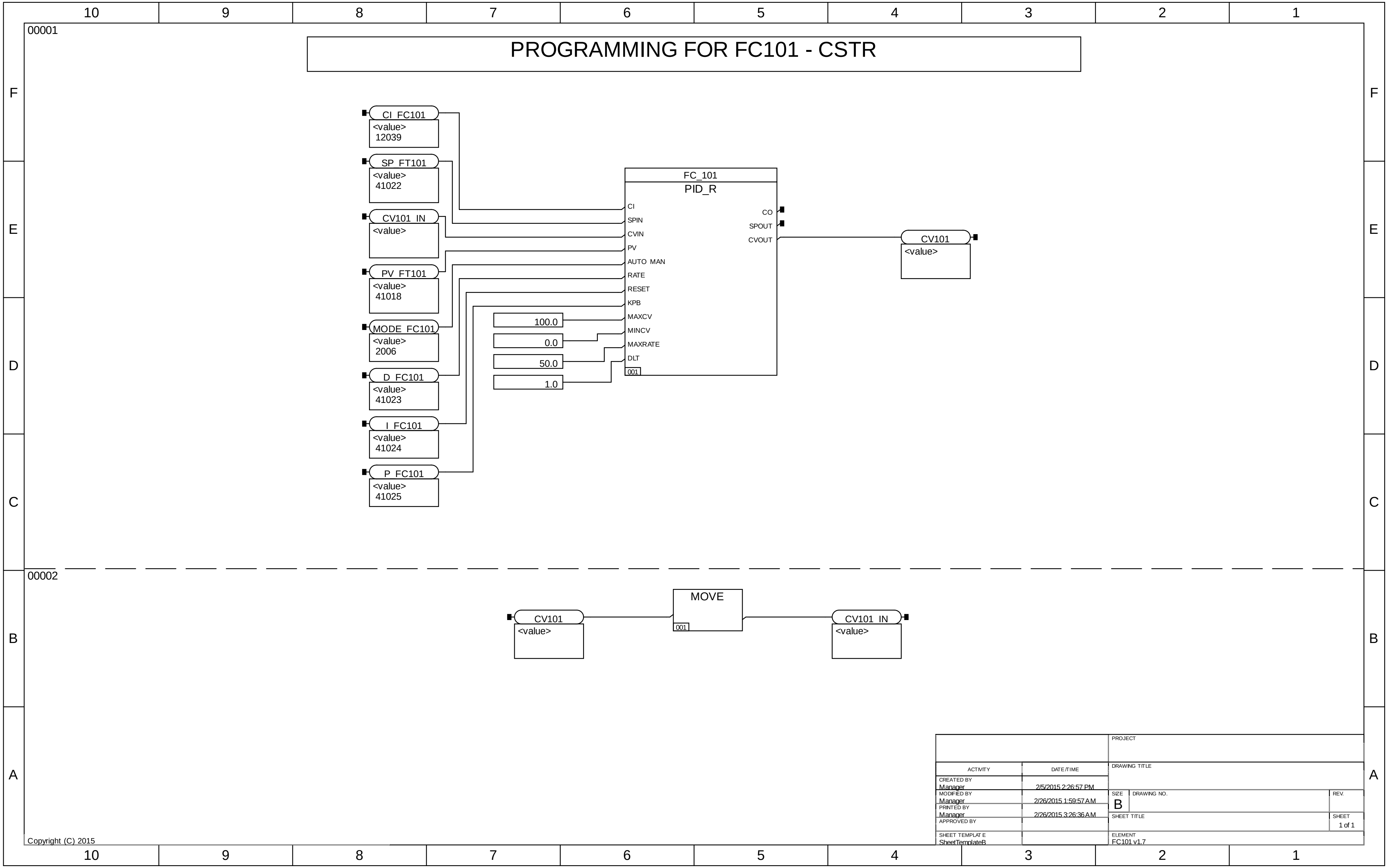
CONTINUOUS STIRRED TANK REACTOR (CSTR)
CAUSE AND EFFECT DIAGRAM

				EFFECT																
				PID NO.																
				ACTION	Field & HMI alarm	Field & HMI alarm	HMI display	HMI display	HMI display	HMI display	Field & HMI alarm	Field & HMI alarm	Field & HMI alarm	Field & HMI alarm	Field & HMI alarm	HMI display	HMI display	Field & HMI alarm	Field & HMI alarm	Field & HMI alarm
				DESCRIPTION	Shutdown valve for reactant A	Shutdown valve for reactant B	Display level HH setpoint at HMI	Display level H setpoint at HMI	Display level L setpoint at HMI	Display level LL setpoint at HMI	Level HH trip in logic and HH alarm at HMI	Level H trip in logic and HH alarm at HMI	Level L trip in logic and HH alarm at HMI	Level LL trip in logic and HH alarm at HMI	Level fault trip in logic and alarm at HMI	Display temperature HH setpoint at HMI	Display temperature H setpoint at HMI	Temperature HH trip in logic and HH alarm at HMI	Temperature H trip in logic and HH alarm at HMI	Temperature fault trip in logic and alarm at HMI
				TAGNAME	SD_101	SD_102	LAHH_HMI_LT101	LAH_HMI_LT101	LAL_HMI_LT101	LALL_HMI_LT101	LAHH_LT101	LAH_LT101	LAL_LT101	LALL_LT101	FLT_LT101	TAHH_HMI_TT101	TAH_HMI_TT101	TAHH_TT101	TAH__TT101	FLT_TT101
CAUSE																				
TAGNAME	DESCRIPTION	STATUS	ORIGIN																	
LT-101	CSTR vessel, produced mixture level	LL	FIELD							X				X						
	CSTR vessel, produced mixture level	L	FIELD						X				X							
	CSTR vessel, produced mixture level	H	FIELD					X				X								
	CSTR vessel, produced mixture level	HH	FIELD		X	X	X				X									
	CSTR vessel, produced mixture level	OC / SC	FIELD												X					
	CSTR vessel, produced mixture level	PV_LT101	FIELD																	
TT-101	CSTR vessel, produced mixture temperature	H	FIELD														X		X	
	CSTR vessel, produced mixture temperature	HH	FIELD													X		X		
	CSTR vessel, produced mixture temperature	OC / SC	FIELD																	X
	CSTR vessel, produced mixture temperature	PV_TT101	FIELD																	
FT-101	CSTR inlet line A	H	FIELD																	
	CSTR inlet line A	HH	FIELD																	
	CSTR inlet line A	OC / SC	FIELD																	
	CSTR inlet line A	PV_FT101	FIELD																	
FT-102	CSTR inlet line B	H	FIELD																	
	CSTR inlet line B	HH	FIELD																	
	CSTR inlet line B	OC / SC	FIELD																	
	CSTR inlet line B	PV_FT102	FIELD																	
SHUTDOWN																				
PT-101	CSTR inlet line A	H	FIELD																	
	CSTR inlet line A	HH	FIELD		X															
	CSTR inlet line A	OC / SC	FIELD																	
PT-102	CSTR inlet line B	H	FIELD			X														
	CSTR inlet line B	HH	FIELD																	
	CSTR inlet line B	OC / SC	FIELD																	
PT-103	CSTR vessel, measure pressure in tank	H	FIELD		X	X														
	CSTR vessel, measure pressure in tank	HH	FIELD																	
	CSTR vessel, measure pressure in tank	OC / SC	FIELD																	

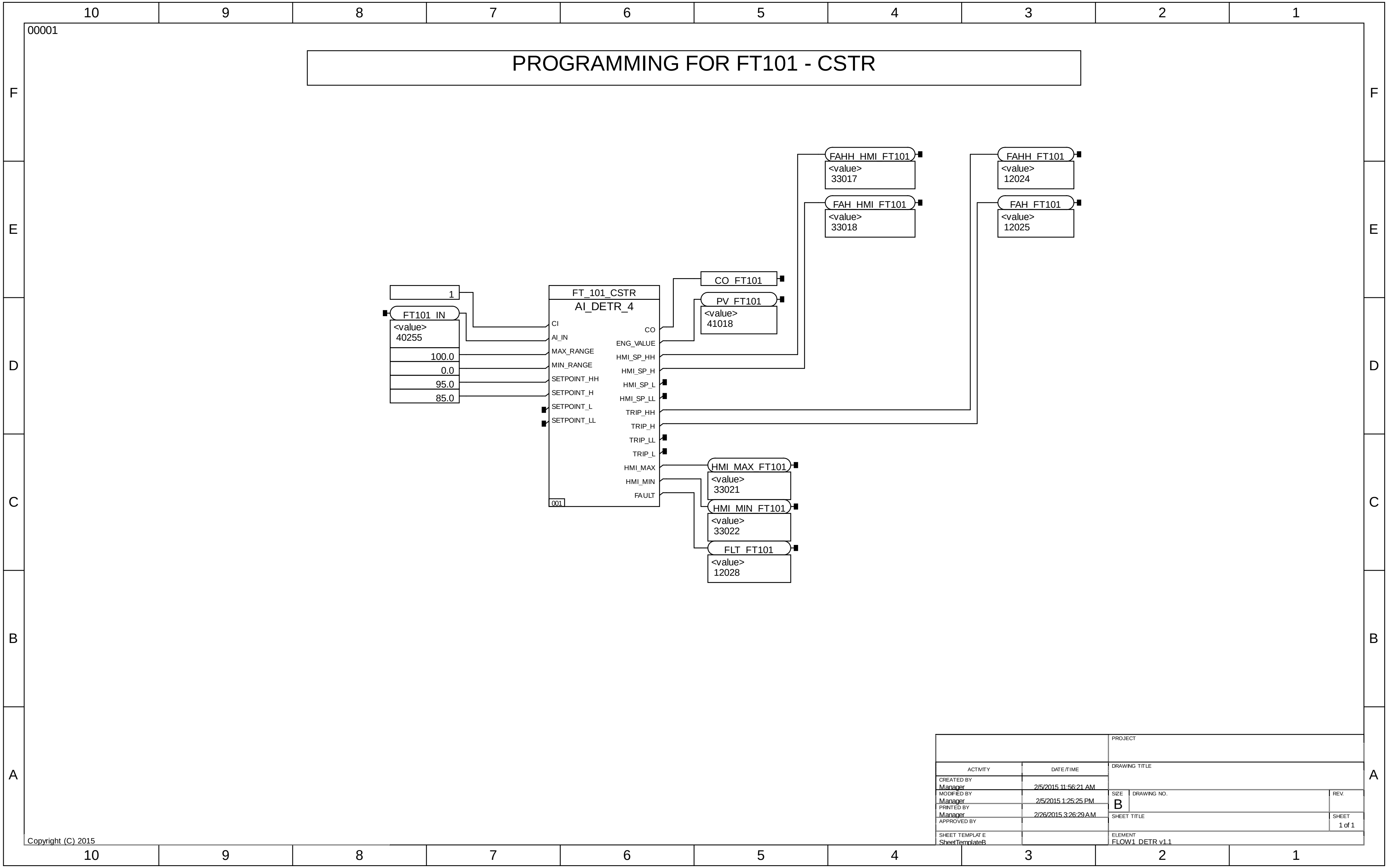
		EFFECT															
		PID NO.															
		ACTION	HMI display	HMI display	Field & HMI alarm	Field & HMI alarm	Field & HMI alarm	HMI display	HMI display	Field & HMI alarm	Field & HMI alarm	Field & HMI alarm	HMI display	HMI display	Field & HMI alarm	Field & HMI alarm	Field & HMI alarm
		DESCRIPTION	Display flow HH setpoint at HMI	Display flow H setpoint at HMI	Flow HH trip in logic and HH alarm at HMI	Flow H trip in logic and HH alarm at HMI	Flow fault trip in logic and alarm at HMI	Display flow HH setpoint at HMI	Display flow H setpoint at HMI	Flow HH trip in logic and HH alarm at HMI	Flow H trip in logic and HH alarm at HMI	Flow fault trip in logic and alarm at HMI	Display pressure HH setpoint at HMI	Display pressure H setpoint at HMI	Pressure HH trip in logic and HH alarm at HMI	Pressure H trip in logic and HH alarm at HMI	Pressure fault trip in logic and alarm at HMI
		TAGNAME	FAHH_HMI_FT101	FAH_HMI_FT101	FAHH_FT101	FAH__FT101	FLT_FT101	FAHH_HMI_FT102	FAH_HMI_FT102	FAHH_FT102	FAH__FT102	FLT_FT102	PAHH_HMI_PT101	PAH_HMI_PT101	PAHH_PT101	PAH__PT101	FLT_PT101
TAGNAME	STATUS																
LT-101	LL																
	L																
	H																
	HH																
	OC / SC																
	PV_LT101																
TT-101	H																
	HH																
	OC / SC																
	PV_TT101																
FT-101	H			X		X											
	HH		X		X												
	OC / SC						X										
	PV_FT101																
FT-102	H								X		X						
	HH							X		X							
	OC / SC											X					
	PV_FT102																
SHUTDOWN																	
PT-101	H													X		X	
	HH												X		X		
	OC / SC																X
PT-102	H																
	HH																
	OC / SC																
PT-103	H																
	HH																
	OC / SC																

		EFFECT																	
		PID NO.											FC_101	FC_102	TC_101_B	LC_101_A			
		ACTION	HMI display	HMI display	Field & HMI alarm	Field & HMI alarm	Field & HMI alarm	HMI display	HMI display	Field & HMI alarm	Field & HMI alarm	Field & HMI alarm	Direct PID control	Direct PID control	Direct PID control	Direct PID control	Automated	Automated	Automated
		DESCRIPTION	Display pressure HH setpoint at HMI	Display pressure H setpoint at HMI	Pressure HH trip in logic and HH alarm at HMI	Pressure H trip in logic and HH alarm at HMI	Pressure fault trip in logic and alarm at HMI	Display pressure HH setpoint at HMI	Display pressure H setpoint at HMI	Pressure HH trip in logic and HH alarm at HMI	Pressure H trip in logic and HH alarm at HMI	Pressure fault trip in logic and alarm at HMI	Control valve at CSTR inlet line A	Control valve at CSTR inlet line B	Control valve at CSTR product line	Control valve at CSTR cooling water outlet line	Pump at product line	Pump at cooling water output line	CSTR stirrer motor
		TAGNAME	PAHH_HMI_PT102	PAH_HMI_PT102	PAHH_PT102	PAH__PT102	FLT_PT102	PAHH_HMI_PT103	PAH_HMI_PT103	PAHH_PT103	PAH__PT103	FLT_PT103	CV101	CV102	CV103	CV104	M103	M104	M105
TAGNAME	STATUS																		
LT-101	LL																		
	L																		
	H																		
	HH																		
	OC / SC																		
	PV_LT101														X				X
TT-101	H																		
	HH																		
	OC / SC																		
	PV_TT101															X	X	X	
FT-101	H																		
	HH																		
	OC / SC																		
	PV_FT101												X						
FT-102	H																		
	HH																		
	OC / SC																		
	PV_FT102													X					
SHUTDOWN																			
PT-101	H																		
	HH																		
	OC / SC																		
PT-102	H			X		X													
	HH		X		X														
	OC / SC						X												
PT-103	H								X		X								
	HH							X		X									
	OC / SC											X							

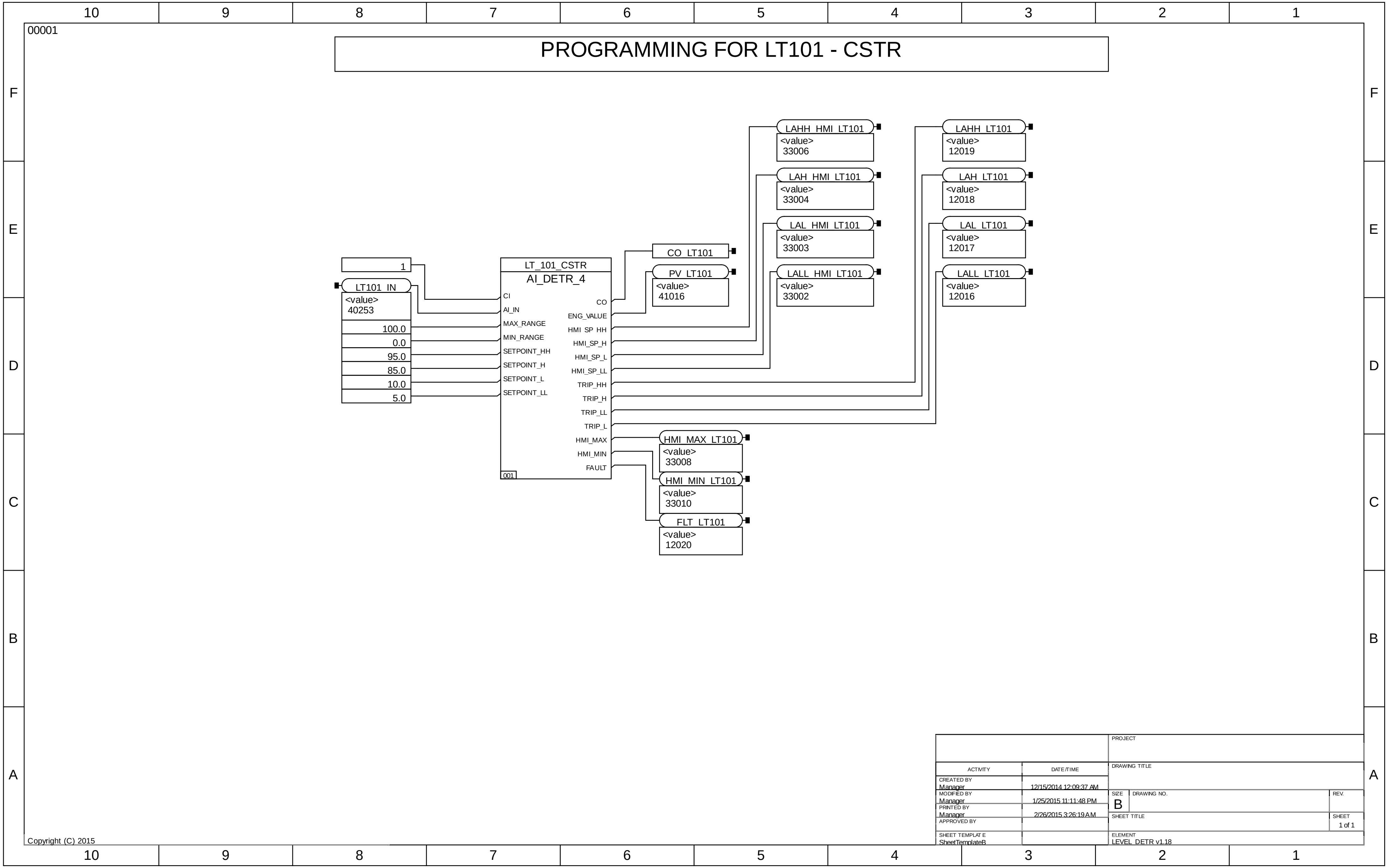
APPENDIX 4-i – EXAMPLE OF FBD PROGRAMMING



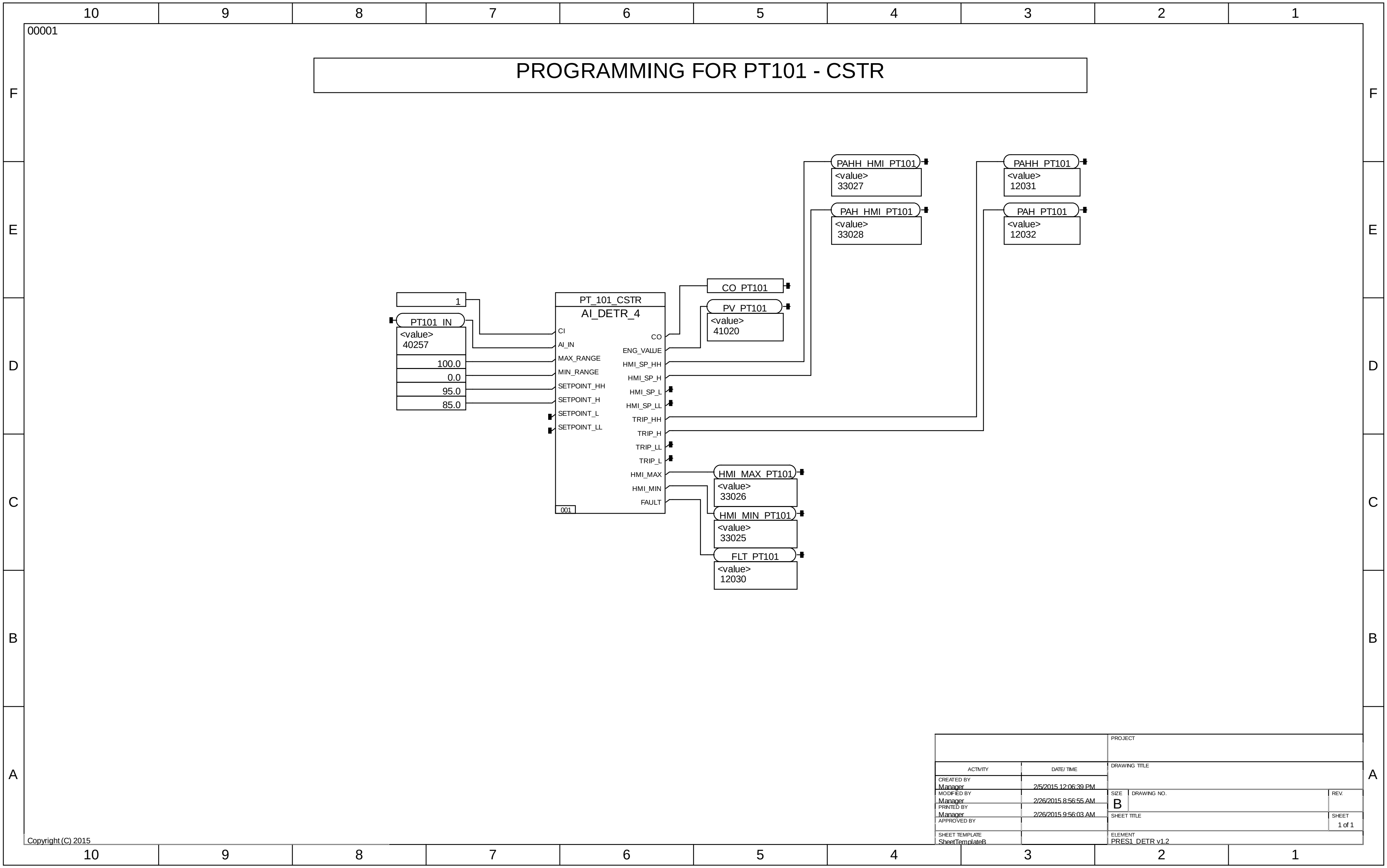
APPENDIX 4-ii – EXAMPLE OF FBD PROGRAMMING



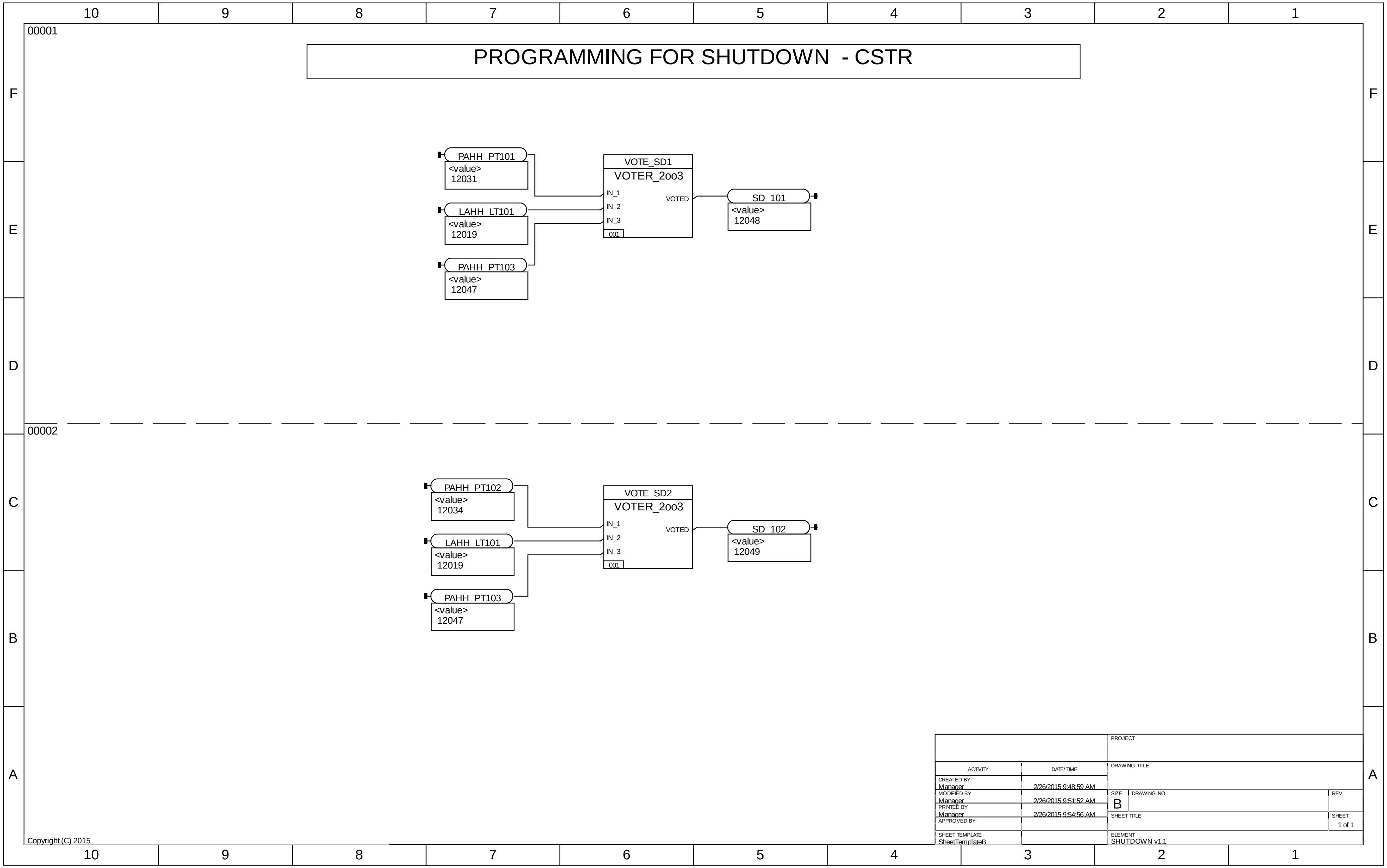
APPENDIX 4-iii – EXAMPLE OF FBD PROGRAMMING



APPENDIX 4-iv – EXAMPLE OF FBD PROGRAMMING



APPENDIX 4-v – EXAMPLE OF FBD PROGRAMMING



APPENDIX 4-vi – EXAMPLE OF FBD PROGRAMMING